

Ethnobotany of edible plants in Muang District, Kalasin Province, Thailand

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Abstract. Phatlamphu N, Saensouk S, Saensouk P, Jungsongduang A. 2021. *Ethnobotany of edible plants in Muang District, Kalasin Province, Thailand. Biodiversitas* 22: 5432-5444. Edible plants have been used as a food source and have had other purposes since ancient times, but urbanization and modernization might be obscuring traditional knowledge. Therefore, this research aimed to conduct a study on the ethnobotany of indigenous people in Muang District, Kalasin Province based on edible plants by focusing on their specific uses. Data was collected through semi-structured interviews and focus group discussions from March 2019 to February 2021. Quantitative analysis was applied using the Cultural Important Index (CI), Fidelity Level (FL) and Informant Consensus Factor (ICF). Cluster analysis based on the Jaccard's Similarity Index (JI) was calculated for the similarity of edible plant uses in four communities is as follows: urban/semi-urban (UB), forest community (FC), wetland community (WC) and community in valley (CV). There were 140 edible plant species that belonged to 125 genera and 62 families. The most important edible plants species were *Tamarindus indica* which had a CI of 2.65 followed by *Bambusa bambos* (2.00) and *Citrus hystrix* (1.90). The highest FL value is given for 51 edible plant species with 100% FL. The ICF is a range of 0 to 1; the most consensus of ailment categories was the treatment of wound (ICF = 1.00). The JI varied between 0.2640 and 0.2971; the highest JI was the pairs of WC and FC. UPGMA cluster analysis indicated that UB is isolated as they have less similarity to other communities. The results show a risk of traditional knowledge loss due to the expansion of the economic system at all levels and the advancement of modern medicine.

Keywords: Edible plants, ethnobotany, Isan region, Kalasin Province, Similarity Index

Abbreviations: CI: Cultural Important Index, FL: Fidelity Level, ICF: Informant Consensus Factor, JI: Jaccard's Similarity Index

INTRODUCTION

Plants are a special kingdom of organisms as they can produce their own energy through the main elements and sunlight, and they offer benefits to other kingdoms of life. Humans have used plants as food, drugs and to meet other needs since ancient times (Fernando 2012; Katiyar et al. 2021; Saensouk and Saensouk 2021). However, the species diversity of plants gives a variety of plant uses depending on their form and culture in each region around the world. Therefore, edible plants have other essential uses in addition to food for people (Saensouk et al. 2016; Saisor et al. 2021).

Thailand is a country in Southeast Asia, which is located in the tropical zone and comprised of several distinct geographic regions; this has resulted in rich biodiversity in Thailand. From past to present, Thai people have used natural products. Several things had been made from the wild ingredients that are fundamental factors in human life (foods and medicines) and as tools to solve basic problems, such as the creation of artifacts or houses that are built from different hardwood plant species, and these help people seek a better livelihood. This is reflected

by Thailand having been historically a country with extensive knowledge of traditional plant uses (Robinson 2007).

The Northeast of Thailand or "Isan Region" is the largest and most populous region in Thailand (25,000 km²), and is located on the part of the Khorat Plateau (14-19°N, 101-106°E) (Cheonkwan et al. 2021). There are 11 main ethnic groups of indigenous people in the Isan region, and the biggest group is the Thai Isan (Thai Lao) which is characterized by the settlement of two ethnic groups between Thai and Lao people (United Nations 2011). This is a reason for the knowledge sharing by local people on the properties of food and traditionally used plants. For over four decades, rice farming has become the main commercial crop of the Isan Region (Cramb 2020). The Isan region has undergone a major change in the structure of land uses due to socio-economic drivers and the large industry in agriculture (Grünbühel 2003). There is an area cultivated to grow cash crops that provides a major source of agricultural raw materials (such as sugarcane, cassava, rubber, rice, etc.) as inputs for nearby factories. This has a huge effect on land-use change to that of the indigenous people.

Kalasin is one of 20 provinces in the Isan Region that faces a problem about traditional knowledge loss caused by land-use change and the expansion of the economy and utility system, which is in accordance with other ethnobotanical studies in Thailand and other countries (Kayani et al. 2015; Khuankaew et al. 2014; Reyes-García et al. 2013; Srithi et al. 2009). Some parts of forest areas have been turned into cultivation areas and housing, which might be the cause of the loss of diversity in edible plant species.

Therefore, the ethnobotany of edible plants in Muang District, Kalasin Province, was surveyed to study the plant species diversity and their uses with a focus on local cultural values, and then this information was applied to sustain the use of the resources and for nature conservation. In addition, more benefits for the people could be developed their own traditional knowledge.

MATERIALS AND METHODS

Study area

Kalasin Province is located in the center of northeastern Thailand ($16^{\circ}25'56.5''\text{N}$ $103^{\circ}30'28.3''\text{E}$) (Figure 1). Kalasin is covered by a hilly landscape with dispersed ponds and swamps. The total area is 6,936 square kilometers. Normally, the weather is hot in the summer and quite cold in the winter. Muang District has an area of around 691.524 square kilometers. The area consists of valleys and plains with an altitude of around 140-250 meters above sea level.

There are mixed social patterns between urban and rural populations with 146,194 people in 17 sub-districts. Most of the population works in agriculture-related jobs (Kalasin Provincial Office SIPD 2013).

Data collection

The ethnobotany of edible plants in Muang District, Kalasin Province was collected between March 2019 and February 2021. The uses of edible plants were collected by the semi-structured interview method through randomly selected key participants (Numpulsuksant et al. 2021; Saisor et al. 2021; Susandarini et al. 2021) and focus group discussions with 40 informants from 17 sub-districts by random selection of 2-5 people per sub-district. In addition, to the local name and questionnaire about the parts of the edible plants used and consumption methods, their properties when the plants are used to cure diseases and heal patients were collected.

Specimen collection and identification

Plant specimens were collected from fields. Voucher specimens were deposited at the Mahasarakham University Herbarium. Plants specimens were identified to their scientific name based on the information from previous studies in Kalasin and other regions in Northeastern Thailand, using the available literature on plant diversity or the Flora of Thailand book, and verified using an online database, Plants of the World Online or POWO (Kew Science 2021).

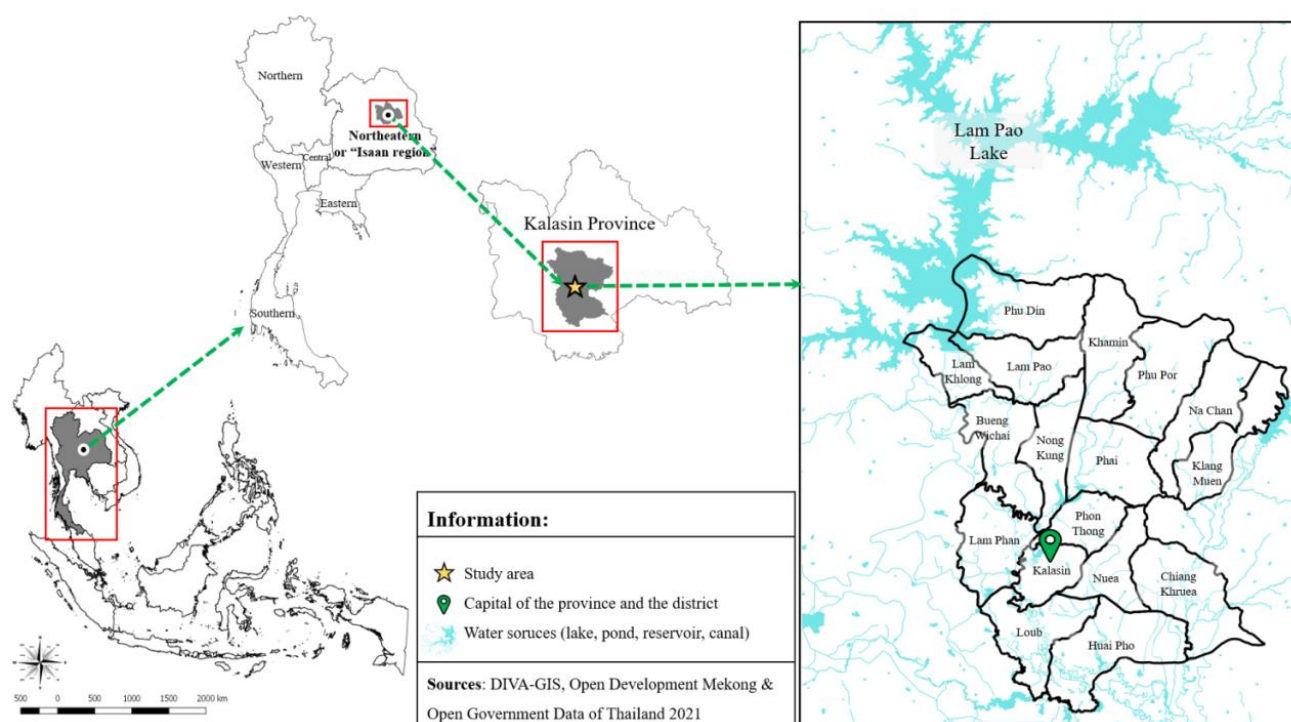


Figure 1. Sub-district level map of Muang district, Kalasin Province, Thailand (Kalasin Provincial Office SIPD 2013)

Quantitative analysis

The analysis of the quantitative data was performed using the ethnobotanical index to calculate the Cultural Importance Index (CI) (Sutjaritjai et al. 2019) and Jaccard's Similarity Index (JI) (Silalahi and Nisyawati 2018)

Cultural importance index; CI

The Cultural Importance Index (CI) was used to demonstrate how important the edible plant was for people based on the data from the questionnaire and interviews about species that were used in daily lives (Tardío et al. 2008) and formulated as follows:

$$CI = \sum_{(u=1)}^{NC} \sum_{(i=1)}^N UR_{Ui} / N$$

Where NC is the total number of use categories, UR is the total number of use reports and N is the total number of informants. Therefore, the CI index is the sum of the proportion of informants that mention each of the edible plant species for their use categories.

Fidelity level; FL

Fidelity level is used to analyze the most interesting plant species that were used to cure disease in each ailment category (Friedmann et al. 1986; Numpulsuksant et al. 2021).

$$\%FL = (Np / N) \times 100$$

When Np is the number of used reports of that plant species in that ailment, and N is the total number of plant species in that ailment.

Informant consensus factor; ICF

The Informant consensus factor is used to test an agreement of informants (Trotter and Logan 1986). The higher ICF (near 1) means that informants use the plant to treat the same ailments (Heinrich et al. 1998).

$$IAR = (Nur - Nt) / (Nur - 1)$$

When Nur is the used-report of the specific use of the plant in each ailment, and Nt is the total number of plant species used in each ailments

Jaccard's Similarity Index; JI

Jaccard's Similarity Index (JI) were calculated to compare the edible plant utilization in four areas that were dominated by their unique geographic patterns when the local people in Muang District live near natural resources or in areas that are economic zones, as follows: urban/semi-urban (UB), forest community (FC), wetland community (WC) and community in valley (CV). This will help to focus on differences in plant utilization between the four community areas located in different ecosystems and species similarities among the communities were analyzed with UPGMA cluster analysis (Hammer et al. 2001). The formulae are as follows:

$$JSC = c / (a + b + c)$$

When a is the number of edible plant species used in area A, b is in area B and c is the number of edible plant species used in both areas A and B (Jaccard 1902).

RESULTS AND DISCUSSION

Number of species uses and edible plant families

We found 140 edible plant species belonging to 125 genera and 62 families. The Fabaceae had the highest number (14 species) of edible plant species followed by Lamiaceae and Zingiberaceae (seven species in each family) and Apiaceae (six species) (Table 1). This was in accordance with Thongpukdee et al. (2014) who stated that Fabaceae had the highest number of species members utilized as vegetables in Huai Mek District, Kalasin Province. Punchay et al. (2020) stated that Fabaceae and Zingiberaceae had the highest number of edible plants used by two ethnic groups of local people (Thai Karen and Lawa) from northern Thailand. In a previous study, Cruz-Garcia et al. (2016) indicated that Fabaceae was the most common family found in rice field ecosystems in Kalasin Province. This confirms other ethnobotany research projects (Junsongduang et al. 2013; Ong and Kim 2017; Pholhiamhan et al. 2017). Fabaceae is of great ethnobotanical importance in indigenous and urban communities throughout the world, and this family is one of the largest plant families in the world, including 751 genera and 19,500 species (Christenhusz and Byng 2016; Molares and Ladio 2011). This family has been widely used for food consumption and a variety of other purposes by people. In this study, Fabaceae was used as food by indigenous and urban communities, and some species are used by folk healers for the treatment of different diseases (Rahman and Parvin 2014). This was in accordance with other research projects on Fabaceae state that legume species are more intimated to the indigenous people and important to the health of people around the world (Gwalwanshi et al. 2014; Oladeji et al. 2021; Sutjaritjai et al. 2019). While, thirty-two plant families gave the lowest number of edible plant species (one species each) and they were used by a smaller number of people.

The sub-district with the highest number of edible plant species was Klang Muen (107 species) followed by Phu Por and Lam Khlong giving 98 and 96 species, respectively. Most of the edible plants found in Klang Muen and Lam Klong are not used for food, but rather by the folk healers who still keep and transfer the traditional medicine knowledge to their descendants in those two sub-districts in Muang District, Kalasin Province. Most of the edible plant species found in Phu Por were used for food. Phu Por is a sub-district located in the crop-valley ecosystem which is distant from the local market, and the main occupation of the people in Phu Por is agricultural. They plant a lot of home gardens for food supply adapted to the season and environment aspects. Whereas, Loup sub-district has the lowest number (61 species). However, the number of edible plant species found in Loup was not different from five other sub-districts, such as Nuea (63 species), Phai (64 species) and Phu Din, Nong Kung and

Khamin (65 species) (Figure 2). In addition, 51 species of edible plant were used in all sub-districts and 35 species were used in only a single sub-district (Figure 3). Therefore, from the results shown in Figure 2 and Figure 3

it can be concluded that there are unnoticed able differences in the number of edible plants used when compared to the number of edible species based on the sub-district administrative/municipality area.

Table 1. Twelve most common plant families are used by local people in Muang District, Kalasin Province, Thailand

Family	Number of species
Fabaceae	15
Lamiaceae, Zingiberaceae	7
Apiaceae	6
Solanaceae	5
Amaryllidaceae, Apocynaceae, Asteraceae, Cucurbitaceae, Euphorbiaceae, Moraceae, Poaceae	4
Acanthaceae, Anacardiaceae, Annonaceae, Malvaceae, Myrtaceae, Rhamnaceae, Rutaceae	3
Arecaceae, Bignoniaceae, Brassicaceae, Meliaceae, Menispermaceae, Phyllanthaceae, Piperaceae, Smilacaceae	2
Alismataceae, Amaranthaceae, Araceae, Basellaceae, Caricaceae, Celastraceae, Cleomaceae, Clusiaceae, Colchicaceae, Connaraceae, Convulvulaceae, Costaceae, Dracaenaceae, Fagaceae, Hypericaceae, Irvingiaceae, Lauraceae, Lecythidaceae, Loganiaceae, Lythraceae, Melastomaceae, Muntingiaceae, Musaceae, Nelumbonaceae, Nymphaeaceae, Opiliaceae, Oxalidaceae, Plantaginaceae, Polygonaceae, Sapindaceae, Sapotaceae, Simaroubaceae	1

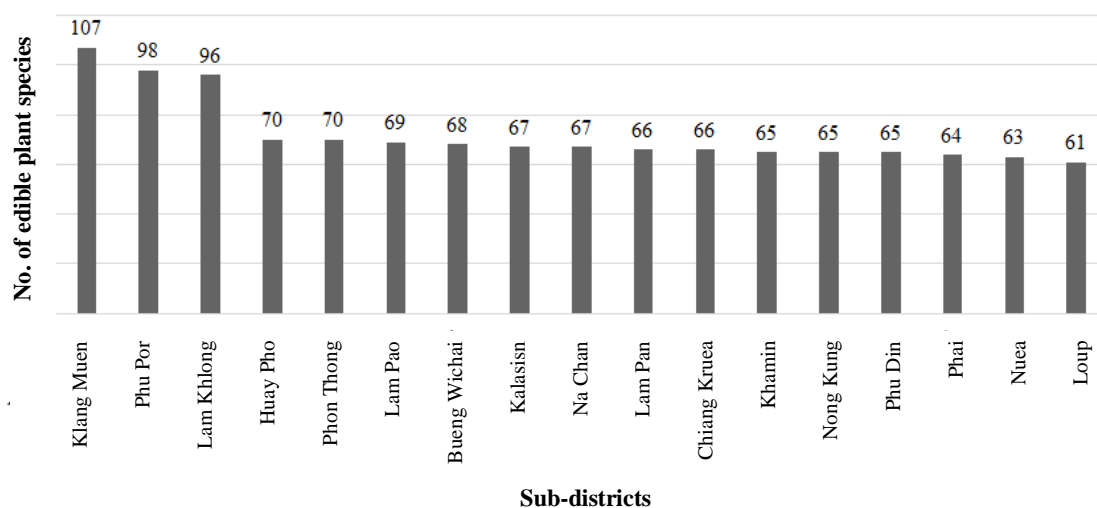


Figure 2. Number of edible plants used by local people in 17 sub-districts in Muang District, Kalasin Province, Thailand

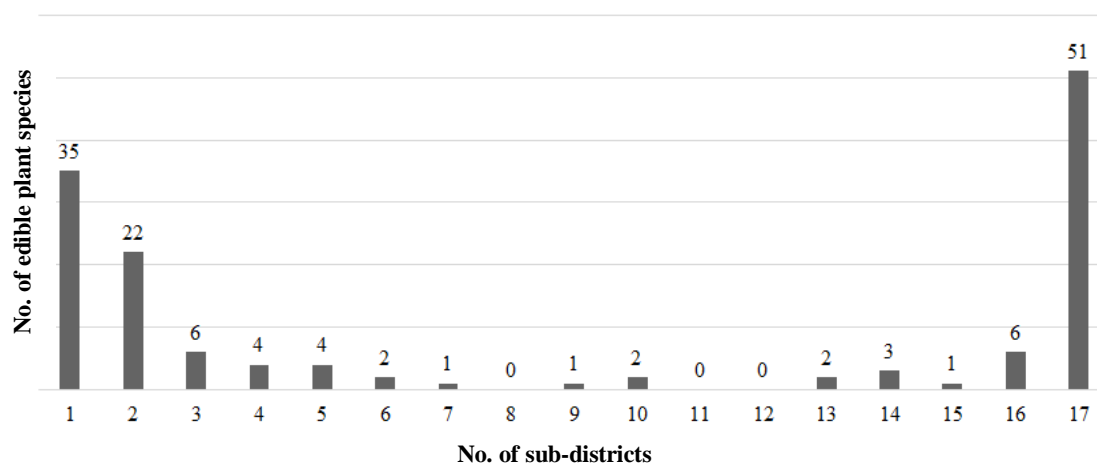


Figure 3. Frequency of occurrence of edible plants species in 17 sub-districts in Muang District, Kalasin Province, Thailand

Cultural important index (CI)

The edible plants that were used in several categories and mentioned by a high number of informants tended to have high CI values. On the other hand, the edible plant species with the lowest CI values were used by a few people. *Tamarindus indica* had the highest CI (2.65) followed by *Bambusa bambos* (2.00) and *Citrus hystrix* (1.90). *Tamarindus indica* is the edible plant used as a fruit, and their young leaves can be used in cooking to give a sour flavor by transforming into a tamarind pulp. Moreover, *T. indica* can be used for other purposes. Their fruit can be used as a laxative; the heartwood is used as a traditional way to care for women after giving birth. Tamarin's stem can be used to make furniture, tools and for building a residence. In addition, tamarind is used in local beliefs, including worship or ceremonies in the Isan traditional culture. Several people grow tamarind trees at the front of their house, as they believe that tamarind would help the inhabitant get respect from other people. While *B. bambos* was used for its shoots for foods and its stem can be used for several purposes. According to an ethnobotany study of bamboo used in the Sangirese (North Celebes), bamboo can be used as a construction material, handicraft, furniture and food (Liana et al. 2017). *Citrus hystrix* has its fruit and leaves used by cooks to make food fragrant and appetizing. In traditional medicine, *C. hystrix* is used as an ingredient in a traditional formula to make Thai herbal compress balls (Wongpanit et al. 2018) which are steamed before being applied to the human body in traditional Thai massages. Moreover, *C. hystrix* is also used to prevent malodor, which is caused by bacteria (Khuntayaporn and Suksiriworapong 2017). The lowest CI (0.03) was found for 20 species of edible plants that were used in traditional ways to cure sicknesses which are known by only a few informants who are elder folk healers (Table 2). Therefore, this is a key conclusion about the conservation of local wisdom when the knowledge is only kept by a few people and there is a risk of knowledge loss due to the

development of public health systems where people can access good quality primary health care and antibiotics. Similarly, with the ethnobotany of traditional medicinal plants studied the Dayak Desa community in Sintang (West Kalimantan, Indonesia) and the traditional study of medicinal plants in Kampung Masjid Ijok (Perak, Malaysia), the traditional knowledge of the medicinal plants was only known by the older generation and there is a risk of knowledge loss due to modern medicine and a change in health care culture (Supiandi et al. 2019; Ramli et al. 2021).

Fidelity level (FL) and Informant consensus factor (ICF)

Two folk healers and their patients have used 68 edible plants as their traditional medicinal remedies (48.22% of total edible species found in a study area) to cure diseases and any symptoms separated for 15 major ailment categories based on National List of Essential Medicines (Natural Drug Information 2013) (Table 3). Fifty-one species were given 100% of FL when they were used in a single category; for example, *Curcuma comosa* are applied to rejuvenate a woman as the traditional postpartum healing (Noomhorm et al. 2014), *Thumbergia laurifolia* is used to neutralize in some venomous insects (Vongthip et al. 2021), etc. Meanwhile, the ICF varied between 0.00-1.00; the highest value was giving a high degree of consensus for injuries when *Chromolaena odorata* was used to stop bleeding after small accidents (Pandith et al. 2013). However, the lower FL means that a plant species is being used for many ailments and the lowest ICF was recorded for seven categories (ICF = 0) when the number of plant use-record was equal to the number of plant species, these results shown that the variety of plant uses in each lowest categories and their properties are known by a few numbers of informants, nor people have less knowledge about traditional medicine (Inta et al. 2013).

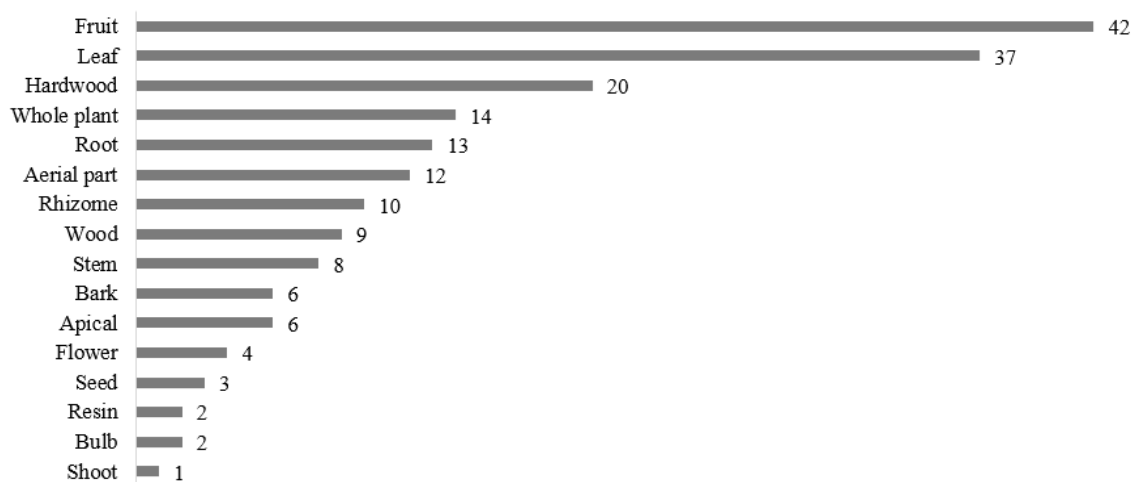


Figure 4. Edible plant parts used in Muang District, Kalasin Province, Thailand

Table 2. Family and scientific names of edible plant species used in Maung District, Kalasin Province, Thailand

Family	Scientific name	Local name	*Use categories	FL (%)	Instruction	CI	Collector no.
Acanthaceae	<i>Andrographis paniculata</i>	Fa thalai chon	Me	100	Boil whole plant to cough relief.	0.25	Phatlamphu097
Acanthaceae	<i>Barleria lupulina</i>	Salet phang phon	Me	100	Pound leaf and mix with alcohol to cure the skin disease.	0.18	Phatlamphu098
Acanthaceae	<i>Thunbergia laurifolia</i>	Rang chuet	Me	100	Pound leaf with water and masking to treat the venomous.	0.10	Phatlamphu099
Alismataceae	<i>Limncharis flava</i>	Phak pai	Fo	-	Eaten fresh as vegetable.	0.98	Phatlamphu139
Amaranthaceae	<i>Achyranthes aspera</i>	Phan ngu	Me	100	Boil and drink for diuresis.	0.03	Phatlamphu129
Amaryllidaceae	<i>Allium ascalonicum</i>	Homdaeng	Fo	-	Used as food ingredients.	1.00	Phatlamphu028
Amaryllidaceae	<i>Allium fistulosum</i>	Hombua	Fo	-	Eaten as vegetable or used as food ingredients.	1.00	Phatlamphu029
Amaryllidaceae	<i>Allium sativum</i>	Kra thiam	Fo, Me	100	Eaten as vegetable or used as food ingredients, Boil the dry false stem and dry leaf mix with water and bath to treat the skin disease.	1.08	Phatlamphu031
Amaryllidaceae	<i>Allium tuberosum</i>	Kui chai	Fo	-	Eaten as vegetable or used as food ingredient.	0.15	Phatlamphu030
Anacardiaceae	<i>Gluta usitata</i>	Rak yai	Me	100	Boil bark and drink to cure stomachache.	0.10	Phatlamphu091
Anacardiaceae	<i>Mangifera indica</i>	Mak muang	Fo	-	Eaten as fruit.	1.00	Phatlamphu135
Anacardiaceae	<i>Spondias pinnata</i>	Mak kok	Fo	-	Used as food flavoring.	0.65	Phatlamphu049
Annonaceae	<i>Annona squamosa</i>	Makkhie	Fo, Me	100	Eaten as fruit, rubbing dry fruit mix with water to cure abscess.	0.13	Phatlamphu138
Annonaceae	<i>Polyalthia debilis</i>	Kluai tao	Me	100	Boil whole plant and drink to cure diarrhea.	0.03	Phatlamphu114
Annonaceae	<i>Polyalthia evecta</i>	Nom noi	Me	100	Boil root and drink abdominal distention.	0.05	Phatlamphu115
Apiaceae	<i>Anethum graveolens</i>	Thian khao plueak	Fo	-	Eaten as vegetable or used as food ingredient.	1.00	Phatlamphu017
Apiaceae	<i>Apium graveolens</i>	Khuen-chai	Fo	-	Eaten as vegetable or used as food ingredient.	0.35	Phatlamphu018
Apiaceae	<i>Centella asiatica</i>	Bua bok	Fo	-	Eaten as vegetable.	0.38	Phatlamphu004
Apiaceae	<i>Coriandrum sativum</i>	Phak chi	Fo	-	Eaten as vegetable or used as food ingredient.	0.98	Phatlamphu015
Apiaceae	<i>Eryngium foetidum</i>	Hom phe	Fo	-	Eaten as vegetable or used as food ingredient.	1.00	Phatlamphu016
Apiaceae	<i>Oenanthe javanica</i>	Phak chi lom	Fo	-	Eaten as vegetable.	0.93	Phatlamphu019
Apocynaceae	<i>Carissa carandas</i>	Nam daeng	Fo	-	Eaten as fruit.	0.15	Phatlamphu133
Apocynaceae	<i>Cryptolepis buchananii</i>	Thao en on	Me	50	Boil hardwood and drink to cough relief	0.08	Phatlamphu116
				50	Boil leaf mix with water and bath to rejuvenate as the traditional postpartum healing		
Apocynaceae	<i>Myriopterion extensum</i>	Cha em	Fo	-	Eaten as vegetable or used as food ingredient.	0.13	Phatlamphu076
Apocynaceae	<i>Streptocaulon juvenas</i>	Khreau prasong	Me	100	Boil root and drink to cure stomachache.	0.03	Phatlamphu117
Araceae	<i>Amorphophallus brevispathus</i>	Elok	Fo	-	Used as food ingredients.	0.50	Phatlamphu136
Arecaceae	<i>Calamus viminalis</i>	Wai khom	Fo, Eq	-	Used as food ingredients, used the stem as the equipment.	1.10	Phatlamphu137
Arecaceae	<i>Cocos nucifera</i>	Mak phrao	Fo	-	Eaten as fruit.	1.00	Phatlamphu005
Asteraceae	<i>Artemisia lactiflora</i>	Ching-chu-chai	Fo	-	Eaten as vegetable or used as food ingredient.	0.05	Phatlamphu075
Asteraceae	<i>Blumea balsamifera</i>	Nat yai	Me	100	Bring leaf lie by the fire as the traditional postpartum healing.	0.25	Phatlamphu120
Asteraceae	<i>Chromolaena odorata</i>	Sap suea	Me	25	Boil fresh root and drink to cure stomachache.	0.03	Phatlamphu121
				75	Pound leaf and masking wound to stop bleeding.		
Asteraceae	<i>Pluchea indica</i>	Khlu	Me	100	Squash leaf mix with water to cure hemorrhoid.	0.03	Phatlamphu118
Athyriaceae	<i>Diplazium esculentum</i>	Phak kut khao	Fo	-	Eaten as vegetable.	0.15	Phatlamphu079
Basellaceae	<i>Basella alba</i>	Phak plang	Fo	-	Eaten as vegetable.	0.18	Phatlamphu080
Bignoniaceae	<i>Dolichandrone serrulata</i>	Khae Na	Fo	-	Eaten as vegetable.	0.35	Phatlamphu078
Bignoniaceae	<i>Oroxylum indicum</i>	Lin fah	Fo	-	Used as food ingredients.	0.88	Phatlamphu026

Brassicaceae	<i>Brassica oleracea</i>	Phak kha na	Fo	-	Eaten as vegetable, used as food ingredient.	0.93	Phatlamphu020
Brassicaceae	<i>Rorippa indica</i>	Phak lin pee	Fo	-	Eaten as vegetable.	0.05	Phatlamphu048
Caricaceae	<i>Carica papaya</i>	Makhoong	Fo, Me	100	Eaten as vegetable, used as food ingredient, used their resin to cure skin disease.	1.03	Phatlamphu054
Celastraceae	<i>Salacia chinensis</i>	Kamphaeng Chet Chan	Me	100	Used stem as the crude drug ingredient to cure hemorrhoid.	0.05	Phatlamphu123
Cleomaceae	<i>Cleome gynandra</i>	Phak sian	Fo	-	Eaten as vegetable or used as food ingredient.	0.85	Phatlamphu067
Clusiaceae	<i>Garcinia cowa</i>	Maksommong	Fo	-	Eaten as vegetable.	0.03	Phatlamphu074
Colchicaceae	<i>Gloriosa superba</i>	Dong dueng	Me	100	Used whole plant as the crude drug ingredient to cure mumps (parotitis).	0.03	Phatlamphu119
Connaraceae	<i>Ellipanthus tomentosus</i>	Kham rok	Me	100	Boil hardwood and drink to cure stomachache.	0.05	Phatlamphu132
Convulvulaceae	<i>Ipomoea aquatica</i>	Phak bung	Fo	-	Eaten as vegetable, used as food ingredient.	1.00	Phatlamphu046
Costaceae	<i>Cheilocostus speciosus</i>	Ueang mai na	Me	100	Boil hardwood and drink to cure dysuria	0.03	Phatlamphu111
Cucurbitaceae	<i>Coccinia grandis</i>	Phak tam lueng	Fo	-	Eaten as vegetable, used as food ingredient.	1.00	Phatlamphu047
Cucurbitaceae	<i>Cucurbita moschata</i>	Makuae	Fo	-	Used as food ingredient.	1.00	Phatlamphu072
Cucurbitaceae	<i>Momordica charantia</i>	Ma ra khi nok	Fo	-	Eaten as vegetable, used as food ingredient.	0.23	Phatlamphu021
Cucurbitaceae	<i>Trichosanthes cucumerina</i>	Buap	Fo	-	Used as food ingredient.	0.03	Phatlamphu073
Dracaenaceae	<i>Dracaena cochinchinensis</i>	Chan Daeng	Me	100	Used hardwood as the crude drug ingredient to cure influenza.	0.03	Phatlamphu094
Euphorbiaceae	<i>Cladogynos orientalis</i>	Chetta phang khi	Me	100	Boil hardwood and drink to cure stomachache.	0.03	Phatlamphu095
Euphorbiaceae	<i>Croton persimilis</i>	Plao yai	Me	100	Bring leaf lie by the fire as the traditional postpartum healing.	0.08	Phatlamphu092
Euphorbiaceae	<i>Euphorbia hirta</i>	Nam nom ratchasi	Me	100	Boil hardwood and drink to cough relief.	0.05	Phatlamphu093
Euphorbiaceae	<i>Suregada multiflora</i>	Khan thong phayabat	Me	100	Used hardwood as the crude drug to cure kidney disease.	0.03	Phatlamphu096
Fabaceae	<i>Acacia pennata</i>	Phak kha	Fo	-	Used as food ingredient.	1.00	Phatlamphu052
Fabaceae	<i>Acrocarpus fraxinifolius</i>	Sadao chang	Me	100	Used hardwood as the crude drug to cure kidney disease.	0.03	Phatlamphu130
Fabaceae	<i>Butea monosperma</i>	Charn	Me	100	Used hardwood as the crude drug to cure kidney disease.	0.03	Phatlamphu023
Fabaceae	<i>Caesalpinia sappan</i>	Fang	Me, Dy	50	Used hardwood as the crude drug ingredient to cure influenza.	0.15	Phatlamphu024
				50	Used stem as the crude drug ingredient to cure hemorrhoid.		
Fabaceae	<i>Cassia fistula</i>	Khun	Me, Cu	100	Bring hardwood lie by the fire as the traditional postpartum healing, local people grown Khun at the front of their house and used their flower in the auspicious ceremony.	0.40	Phatlamphu077
Fabaceae	<i>Clitoria ternatea</i>	Anchan	Me, Dy	100	Pound flower with water as shampoo.	0.15	Phatlamphu122
Fabaceae	<i>Codariocalyx gyroides</i>	Ton khao chi	Me	100	Used fruit as the crude drug ingredient as Leukemia treatment.	0.05	Phatlamphu131
Fabaceae	<i>Leucaena leucocephala</i>	Phak kased	Fo	-	Eaten as vegetable, used as food ingredient.	1.00	Phatlamphu053
Fabaceae	<i>Neptunia prostrata</i>	Phak krachet	Fo	-	Used as food ingredient.	0.80	Phatlamphu128
Fabaceae	<i>Pithecellobium dulce</i>	Mak kham thet	Fo	-	Eaten as fruit.	1.00	Phatlamphu071
Fabaceae	<i>Senna alata</i>	Chumhet thet	Me	100	Used leaf as the crude drug ingredient to cure ringworm.	0.08	Phatlamphu006
Fabaceae	<i>Senna siamea</i>	Khi lek	Fo, Me	100	Used as food ingredient, boil and drink as a laxative.	1.53	Phatlamphu025
Fabaceae	<i>Sesbania gradiflora</i>	Khae	Fo	-	Used as food ingredient.	0.83	Phatlamphu050
Fabaceae	<i>Tamarindus indica</i>	Mak kham	Fo, Me, Eq, Cu	67	Bring hardwood lie by the fire as the traditional postpartum healing, boil and mix with water and bath to wound healing (medicine).	2.65	Phatlamphu022
				33	Eaten as fruit and as a laxative. Eaten as fruit, used as food ingredient (food and medicine).		
					Used stem for building house or equipment, local people grown Mak kham (tamarind) at the front of their house as they believe that Mak kham would help the inhabitant get respect from other people (local belief).		

Fagaceae	<i>Castanopsis piriformis</i>	Kho hin	Me	100	Bring root lie by the fire as the traditional postpartum healing, boil and mix with water and bath to wound healing (medicine).	0.15	Phatlamphu110
Hypericaceae	<i>Cratoxylum formosum</i>	Phak Tio	Fo	-	Eaten as vegetable.	0.93	Phatlamphu043
Irvingiaceae	<i>Irvingia malayana</i>	Bok	Fo, Dy	-	Eaten as fruit, used bark as the dyer.	0.20	Phatlamphu032
Lamiaceae	<i>Mentha × cordifolia</i>	Phak serm	Fo	-	Eaten as vegetable, used as food ingredient.	1.00	Phatlamphu134
Lamiaceae	<i>Ocimum × africanum</i>	Maeng lak	Fo	-	Used as food ingredient.	1.00	Phatlamphu058
Lamiaceae	<i>Ocimum basilicum</i>	Horapha	Fo	-	Eaten as vegetable, used as food ingredient.	1.00	Phatlamphu059
Lamiaceae	<i>Ocimum tenuiflorum</i>	Ka phrao	Fo	-	Used as food ingredient.	1.00	Phatlamphu057
Lamiaceae	<i>Orthosiphon aristatus</i>	Phayab mek	Me	100	Used stem as the crude drug ingredient to muscle pains relief.	0.03	Phatlamphu103
Lamiaceae	<i>Pogostemon cablin</i>	Pim sen	Me	100	Used stem as the crude drug ingredient to muscle pains relief.	0.03	Phatlamphu104
Lamiaceae	<i>Vitex pinnata</i>	Tin nok	Me	50	Boil hardwood and root and drink to cure stomachache.	0.03	Phatlamphu105
				50	Boil hardwood and root and drink to cure diabetes.		
Lauraceae	<i>Cinnamomum camphora</i>	Karabun	Me	100	Used stem as the crude drug ingredient to muscle pains.	0.05	Phatlamphu106
Lecythidaceae	<i>Careya arborea</i>	Kradon	Fo	-	Eaten as vegetable.	0.68	Phatlamphu044
Loganiaceae	<i>Strychnos nux-blanda</i>	Tumka Khao	Me	100	Bring hardwood lie by the fire as the traditional postpartum healing, boil and mix with water and bath to wound healing and drink as Lactagogue.	0.03	Phatlamphu126
Lythraceae	<i>Punica granatum</i>	Mak pila	Fo, Me	33	Boil leaf to cure diarrhea.	0.38	Phatlamphu007
				67	Boil root and drink to cough relief, used root as the crude drug ingredient to cure influenza.		
Malvaceae	<i>Bombax anceps</i>	Ngio pa	Me	50	Boil bark mix with water and drink as a blood tonic.	0.05	Phatlamphu124
				50	Boil bark mix with water and drink as a element tonic (roborant).		
Malvaceae	<i>Helicteres isora</i>	Po bit	Me	100	Bring hardwood lie by the fire as the traditional postpartum healing, boil and mix with water and bath to wound healing and drink as Lactagogue.	0.05	Phatlamphu125
Melastomataceae	<i>Osbeckia stellata</i>	En a khon	Me	100	Pound root with water and masking to treat the venomous, drink as an antidote.	0.05	Phatlamphu102
Meliaceae	<i>Azadirachta indica</i>	Sadao	Fo	-	Eaten as vegetable.	1.00	Phatlamphu068
Meliaceae	<i>Dysoxylum parasiticum</i>	Langsat	Fo	-	Eaten as fruit.	0.10	Phatlamphu065
Menispermaceae	<i>Cissampelos pareira</i>	Krung kha mao	Me	100	Rubbing root and bark mix with water and drink to as a blood tonic.	0.10	Phatlamphu127
Menispermaceae	<i>Tiliacora triandra</i>	Ya nang	Fo	-	Used leaf as food ingredient.	1.00	Phatlamphu033
Moraceae	<i>Artocarpus heterophyllus</i>	Khanun	Fo, Dy, Cu	-	Eaten as fruit, used resin as a dyer, local people grown Khanun (jack-fruit) at the front of their house as they believe that Khanun would help the inhabitant get support from other people in work life (local belief).	1.35	Phatlamphu063
Moraceae	<i>Ficus sarmentosa</i>	Ma kra thueb rong	Me	50	Boil bark mix with water and drink as a blood tonic.	0.03	Phatlamphu101
				50	Boil bark mix with water and drink as a element tonic (roborant).		
Moraceae	<i>Morus alba</i>	Mon	Fo	-	Eaten as fruit.	0.10	Phatlamphu113
Moraceae	<i>Streblus asper</i>	Khoi	Me	100	Used wood as a dental care.	0.05	Phatlamphu109
Muntingiaceae	<i>Muntingia calabura</i>	Mak khop	Fo	-	Eaten as fruit.	1.00	Phatlamphu066
Musaceae	<i>Musa × paradisiaca</i>	Kluai namwa	Fo, Me, Dy, Cu	100	Eaten as fruit, used as crude drug flavoring, used resin as a dyer, used their fruit and aerial part in the auspicious ceremony.	1.50	Phatlamphu008
Myrtaceae	<i>Psidium guajava</i>	Mak see da	Fo	-	Eaten as fruit.	1.00	Phatlamphu009
Myrtaceae	<i>Syzygium antisepticum</i>	Phak mek	Fo	-	Eaten as vegetable.	1.00	Phatlamphu035
Myrtaceae	<i>Syzygium cumini</i>	Wa	Fo	-	Eaten as fruit.	0.58	Phatlamphu010
Nelumbonaceae	<i>Nelumbo nucifera</i>	Bua luang	Fo	-	Eaten as fruit.	0.70	Phatlamphu011
Nelumbonaceae	<i>Nymphaea pubescens</i>	Bua sai	Fo	-	Eaten as vegetable.	0.70	Phatlamphu013
Opiliaceae	<i>Melientha suavis</i>	Phak wan	Fo	-	Eaten as vegetable.	0.88	Phatlamphu014

Oxalidaceae	<i>Averrhoa carambola</i>	Mak fueang	Fo	-	Eaten as fruit.	0.58	Phatlamphu012
Phyllanthaceae	<i>Bauhinia saccocalyx</i>	Siao	Me	100	Boil root and drink as the traditional postpartum healing.	0.03	Phatlamphu082
Phyllanthaceae	<i>Phyllanthus reticulatus</i>	Kang pla khrua	Me	100	Pound root and mix with water and drink as antidote.	0.05	Phatlamphu087
Phyllanthaceae	<i>Sauropus androgynus</i>	Phak wan ban	Fo	-	Eaten as vegetable.	0.08	Phatlamphu045
Piperaceae	<i>Piper nigrum</i>	Phrik thai	Fo	-	Eaten as vegetable, used as food ingredient.	1.00	Phatlamphu041
Piperaceae	<i>Piper sarmentosum</i>	Cha phlu	Fo	-	Eaten as vegetable, used as food ingredient.	1.00	Phatlamphu042
Plantaginaceae	<i>Limnophila aromatica</i>	Phak kha yaeng	Fo	-	Eaten as vegetable, used as food ingredient.	1.00	Phatlamphu056
Poaceae	<i>Bambusa bambos</i>	Phai pa	Fo, Eq	-	Boil and eaten as vegetable, used as food ingredient, used stem as a equipment in daily life.	2.00	Phatlamphu060
Poaceae	<i>Cymbopogon citratus</i>	Ta khrai	Fo, Me	25	Used as compress ball ingredient to pain relief in Thai Massage.	1.00	Phatlamphu034
				75	Bring whole plant lie by the fire as the traditional postpartum healing.		
Poaceae	<i>Oryza sativa</i>	Khao	Fo, Me	100	Eaten as main foods, used as the crude drug to cure kidney disease.	1.00	Phatlamphu140
Poaceae	<i>Saccharum x sinense</i>	Oi dam	Fo, Me	100	Used as crude drug flavoring.	0.30	Phatlamphu100
Polygonaceae	<i>Persicaria odorata</i>	Phak phaeo	Fo	-	Eaten as vegetable.	1.00	Phatlamphu040
Rhamnaceae	<i>Berchemia floribunda</i>	Ho sa phai khwai	Me	50	Boil hardwood mix with water and drink as a blood tonic.	0.05	Phatlamphu108
				50	Boil hardwood mix with water and drink as a element tonic (roborant).		
Rhamnaceae	<i>Ziziphus attopensis</i>	Kamlang suea khrong	Me	50	Boil hardwood mix with water and drink as a blood tonic.	0.23	Phatlamphu027
				50	Boil hardwood mix with water and drink as a element tonic (roborant).		
Rhamnaceae	<i>Ziziphus oenopolia</i>	Lep yiao	Fo, Me	100	Eaten as fruit or as a laxative.	0.35	Phatlamphu069
Rubiaceae	<i>Ixora finlaysoniana</i>	Khem	Me	100	Used as crude drug ingredient to cure hemorrhoid.	0.05	Phatlamphu112
Rubiaceae	<i>Morinda citrifolia</i>	Yo	Fo, Cu	-	Used as food ingredient, local people grown Yo at the front of their house as they believe that Yo would help the inhabitant get praise from other people (local belief).	0.83	Phatlamphu090
Rutaceae	<i>Citrus hystrix</i>	Bak krut	Fo, Me, De	100	Used leaf as food ingredient, cut fruit into pieces and mix with other crude drug ingredients as compress ball ingredient to pain relief in Thai Massage.	1.90	Phatlamphu062
Rutaceae	<i>Citrus x aurantiifolia</i>	Bak nao	Fo, Me	100	Used fruit as food ingredient, used fruit as the crude drug to cure kidney disease.	1.03	Phatlamphu061
Rutaceae	<i>Clausena wallichii</i>	Song fa	Me	100	Boil root and drink to cough relief.	0.08	Phatlamphu081
Sapindaceae	<i>Dimocarpus longan</i>	Lamyai	Fo	-	Eaten as fruit.	1.00	Phatlamphu064
Sapotaceae	<i>Xantolis cambodiana</i>	Tan nom	Me	100	Boil hardwood and drink as a galactagogue.	0.08	Phatlamphu107
Simaroubaceae	<i>Eurycoma longifolia</i>	Pla lai phueak	Me	100	Boil stem and drink and mix with water to bath to cure abscess.	0.08	Phatlamphu086
Smilacaceae	<i>Smilax corbularia</i>	Khao yen nuea	Me	20	Boil fruit mix with water and drink as a blood tonic.	0.10	Phatlamphu083
				20	Boil fruit mix with water and drink as a element tonic (roborant).		
				20	Used as a crud drug ingredient as a Leukemia treatment.		
				40	Boil and drink to cure headache.		
Smilacaceae	<i>Smilax glabra</i>	Khao yen tai	Me	20	Boil fruit mix with water and drink as a blood tonic.	0.10	Phatlamphu084
				20	Boil fruit mix with water and drink as a element tonic (roborant).		
				20	Used as a crud drug ingredient as a Leukemia treatment.		
				40	Boil and drink to cure headache.		
Solanaceae	<i>Capsicum annuum</i>	Phrik	Fo	-	Used as food ingredient.	1.00	Phatlamphu051
Solanaceae	<i>Solanum heterodoxum</i>	Ma khuea	Fo	-	Eaten as vegetable, used as food ingredient.	1.00	Phatlamphu036
Solanaceae	<i>Solanum lasiocarpum</i>	MakUaek	Fo	-	Used as food ingredient.	0.08	Phatlamphu037
Solanaceae	<i>Solanum lycopersicum</i>	Maklen	Fo	-	Eaten as vegetable, used as food ingredient.	1.00	Phatlamphu038

Solanaceae	<i>Solanum stramonifolium</i>	Mak khaeng	Fo, Me	50	Bring hardwood lie by the fire as the traditional postpartum healing (medicine).	1.05	Phatlamphu055
				50	Used fruit as food ingredient, cut fruit into pieces and mix with other crude drug ingredients as compress ball ingredient to pain relief in Thai Massage (medicine).		
					Eaten as vegetable, used as food ingredient (food).		
Sterculiaceae	<i>Mansonia gagei</i>	Chan Hom	Me	100	Used root as crude drug ingredient to cure influenza.	0.08	Phatlamphu085
Zingiberaceae	<i>Alpinia galanga</i>	Kha	Fo	-	Used as food ingredient.	1.00	Phatlamphu039
Zingiberaceae	<i>Boesenbergia rotunda</i>	Krachai	Fo	-	Used as food ingredient.	1.00	Phatlamphu070
Zingiberaceae	<i>Curcuma comosa</i>	Wan chak motluk	Me	33	Used root as crude drug ingredient to pain relief.	0.08	Phatlamphu088
				67	Bring rhizome lie by the fire as the traditional postpartum healing.		
Zingiberaceae	<i>Curcuma longa</i>	Khamin	Fo, Me	25	Used rhizome as crude drug ingredients as compress ball ingredient to pain relief in Thai Massage.	0.33	Phatlamphu003
				75	Bring rhizome lie by the fire as the traditional postpartum healing.		
Zingiberaceae	<i>Curcuma sessilis</i>	Krachiao	Fo	-	Eaten as vegetable.	0.05	Phatlamphu001
Zingiberaceae	<i>Kaempferia galanga</i>	Pro hom	Fo	-	Eaten as vegetable.	0.05	Phatlamphu002
Zingiberaceae	<i>Zingiber montanum</i>	Wan fai	Me	25	Used rhizome as crude drug ingredients as compress ball ingredient to pain relief in Thai Massage.	0.08	Phatlamphu089
				75	Bring rhizome lie by the fire as the traditional postpartum healing.		

Note: * Use categories: Fo: Food, Me: Medicine, Dy: Dyer, Co: Cosmetic, Eq: Equipment, Cu: Culture, Deodorize: De

Table 3. Informant consensus factor (ICF) of used-categories

Used-categories	Treated ailments	Number of use-report	Number of species	ICF
Injuries	Wound, pains	4	2	1.00
Headache	Pain	4	2	0.67
Neutralize, antidote	Venomous insect bite	6	3	0.60
Pregnancy/Birth/Puerperium	Rejuvenate after giving child	35	16	0.56
Skin disorders	Wound, Pain, irritated relief	6	4	0.33
Muscle and skeleton disorders	Muscle pain relief	13	10	0.25
Respiration system	Cough, fever, influenza	12	10	0.18
Digestion system	Diarrhea, Flatulence, stomach ache	17	15	0.13
Endocrine system	Diabetes	1	1	0.00
Urinary system	Dysuria	2	2	0.00
Malignant tumor, Cancer	Supportive treatment	3	3	0.00
Blood tonic	-	6	6	0.00
Element tonic, body strength	Body nourishment	7	7	0.00
Infection	Abscess, Hemorrhoids	6	6	0.00
Other	Crude drug flavouring	2	2	0.00

Table 4. Jaccard's Similarity Index for pairs of communities in the sample of edible plants used in Muang District, Kalasin Province, Thailand

	Urban &semi-urban	Wetland community	Forest community	Community in valley
Urban & Semi-urban	-	0.2829	0.2640	0.2863
Wetland community	-	-	0.2971	0.2877
Forest community	-	-	-	0.2770
Community in valley	-	-	-	-

Jaccard's Similarity Index (JI)

This comparative study classified 17 sub-districts in Muang District, Kalasin Province with their dominant spatial features based on land location or land use pattern into four communities. The JI values were low to average, and varied between 0.2640 and 0.2971 (Table 4). UPGMA cluster analysis showed that the communities with the closest number of edible plant species used were in the same groups, such as WC FC and CV. The cluster diagram separated UB from the other communities to an isolated position, which is apparent from the different land uses (Figure 5). The highest JI was for the pair of WC and FC (0.2971). This shows that these two communities were the most similar community pair as WC and FC were the only two communities that had folk healers who had traditional knowledge about edible plant usage to cure diseases, and they had similar practices for the preparation processes or the same folk medical remedies. This is the reason that these communities have the highest number of edible plant species in both communities (113 and 107 species, respectively). The lowest JI was for the pair of UB and FC (0.2640) when the number of edible plant species used in the capital of the province and the adjacent area is low (71 species), and the people in UB do not use the edible plants

for several purposes. For example, Muang and Loup, which are neighboring sub-districts to the capital of the province, both sub-districts are the location of important places in Kalasin Province, such as the government complex, academic institute, factories and economic zones (municipal market, convenience and department store, restaurants, etc.). This is similarly, to a comparative study using JI values and UPGMA cluster analysis that provided numerical and graphic illustrations of medicinal plant species used in 17 Karen villages in northern Thailand (Tangjitman et al. 2013). Moreover, the edible plants that are used for traditional treatments can be grown in home gardens as important habitats and also in nature conservation, and this is an important factor that ensures rural communities have more edible species in their area (Barbhuiya et al. 2015; Panyadee et al. 2019). However, there is the possibility that the similarity of edible plant uses in Muang District, Kalasin Province are not dependent on the different land uses only, and that communities with a folk healer tend to have a higher number of edible plant uses than the communities without a person with traditional knowledge (Mollik et al. 2010; Biswas et al. 2011). Therefore, it can be concluded that traditional healers are important for plant diversity based on their benefits.

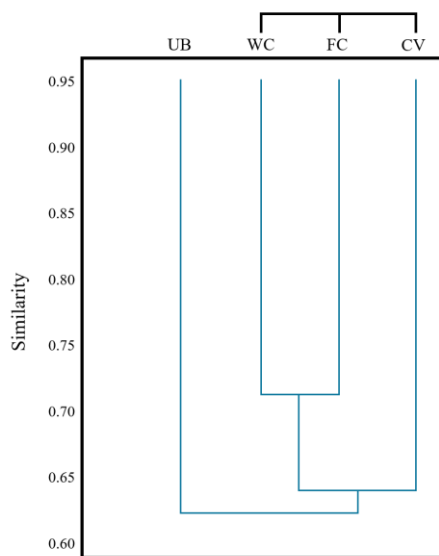


Figure 5. UPGMA cluster analysis of edible plant species used in Muang District, Kalasin Province, Thailand based on Jaccard's Similarity Index. Communities grouped in same square bracket indicate greater similarities between those communities. UB: Urban and semi-urban; WC: wetland community; FC: forest community; and CV: community in valley

The result of this ethnobotanical study shows that the edible plants used in Muang District, Kalasin Province tend to be at risk of traditional botanical knowledge loss due to the expansion of urban areas and the accessibility to modern medicine, and this might have an effect on the diversity of edible plant species that are used as medicine. However, WC, FC and CV represent communities in which people still keep strong knowledge about edible plants that can be used as food and grown in nature and home gardens. This indicates that the indigenous people in Muang District, Kalasin Province have automatically transferred their knowledge of their food culture to their descendants, while knowledge of traditional medicine has not been shared from the old generation to the younger people widely. Therefore, we should be concerned that there is a great amount of knowledge that will forever be lost in the near future; recognition should be given to traditional medicine knowledge and natural resources management by education and providing information or the training programs by the agencies involved. Beyond that, the edible plants could have their appearance transformed to be valuable products for further study. This would help people to secure their income and other benefits that can be obtained from the edible plants.

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